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ENERGY CONTRIBUTIONS ASSOCIATED WITH COMBUSTION INSTABILITY.(U)

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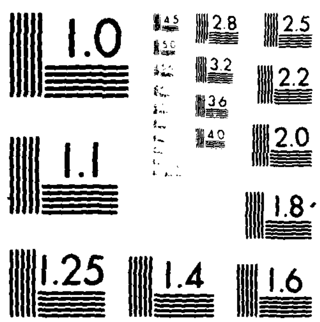

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

NAVSEA Propulsion Research Program

Program Element 61153N

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Energy Contributions Associated with Combustion Instability,

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Annual Progress Report.

1 October 1979 — 30 September 1980,

Background:

Combustion instability is a phenomenon which occurs in a wide variety of thermal energy systems including solid propellant rocket motors. The effects of combustion instability, such as propellant burning rate deviations, excessive heat transfer to motor components, perturbations in motor thrust, and mechanical vibration of the motor case and attached components, are well known and have caused a variety of problems both in the development and the operation of a number of rocket propulsion systems. The instability phenomenon is persistent and requires continued attention from both the research and the development communities.

Understanding of the sources of acoustic energy which give rise to combustion instability has increased considerably in the past decade. However, much remains to be accomplished to improve and extend existing level of combustion instability technology. There are two areas of study which are thought to be capable of yielding useful results in the immediate future. One involves improvements in experimental measurement of the acoustic combustion response of solid propellants. A second area deals with the expansion of combustion stability analysis to include methods for quantitatively describing various acoustic phenomena which are known to occur in rocket motors but which are not adequately incorporated into existing motor stability assessment procedures at the present time.

The persistence of unstable combustion behavior in solid propellant rocket motors requires a level of expertise to be maintained in the field to provide a rapid response to specific instability problems which periodically arise in Navy rocket propulsion systems. The tendency toward more sophisticated missile guidance and control systems and toward more elaborate warheads results in a higher degree of potential for missile or mission failure due to the effects of unstable combustion. The high cost of modern missile development and the increasingly stringent allowances for unstable combustion behavior require continued advancement in understanding of instability and further development of methods for predicting and controlling unstable combustion in solid propellant rocket motors.

Objectives:

(1) To provide improved methods for experimentally determining the acoustic combustion response of solid propellants.

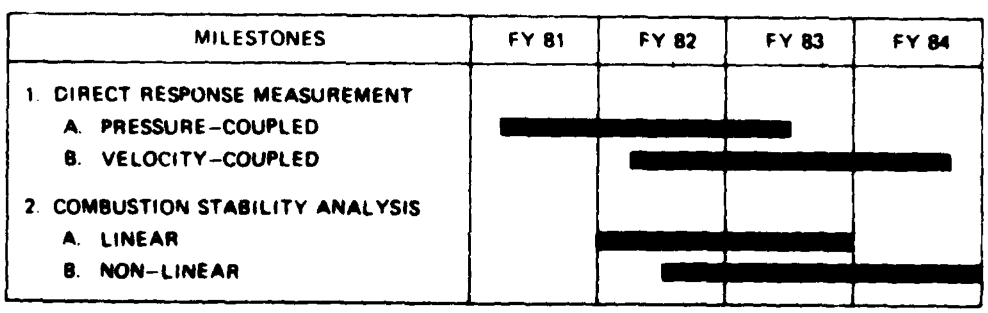
(2) To expand and add to existing combustion stability analysis to provide methods for describing non-linear phenomena and the effects of traveling acoustic waves in rocket motors.

Approach:

The investigation of new and novel laboratory test techniques for determining the acoustic energy contributions of burning propellants will be pursued. Emphasis will be on methods that provide a more direct measurement than presently employed. Initial effort will be focused on methods for directly determining the response of solid propellant combustion to incident acoustic pressure waves. If successful, the method, or methods, for pressure-coupled measurement will be modified to provide direct velocity-coupled response measurements. These methods are expected to lower the cost of characterizing the acoustic combustion response of solid propellant formulations of interest to the Navy and to provide improved accuracy of measurement.

The analytical description of acoustic energy contributions associated with combustion instability will be expanded to provide improvements to both linear and non-linear aspects of acoustic wave phenomena. Typical examples of phenomena requiring attention are: effect of traveling acoustic waves on motor stability, analytical description of mechanisms which impose finite limits on acoustic waves in motors, and description of phenomena associated with "triggered" oscillations in motors. The approach to this portion of the program will require application of both approximate and exact solutions to the appropriate governing equations. Verification of the analytical methods will be accomplished by incorporating the methods into motor stability prediction codes and using the codes to predict motor instability behavior. Comparison of code predictions with actual motor behavior will provide indications of the utility of the method(s).

Milestones:



Budget:

BUDGET	CFY	CFY+1	CFY+2	CFY+3
SALARY	32K	47K	55K	44K
COMPUTER CHARGES	6K	8K	10K	10K
MATERIALS & SHOP CHARGES	7K	10K	10K	6K
TOTAL	45K	65K	75K	60K

Accomplishments:

The work described here is new to this project; work will be initiated in FY 81.

Plans:

CFY

Major emphasis will be placed on developing laboratory techniques for directly measuring the combustion response of solid propellants to an acoustic environment. Initial effort will be on pressure-coupled response and methods for measuring propellant burning rate by microwave techniques. This effort is interdisciplinary in scope and will require coordination between specialists in combustion instability, microwave electronics, and in analog and digital signal processing.

CFY+1

Effort on the use of microwave techniques to measure pressure-coupled combustion response will continue. Experience gained with the pressure-coupled portion of the project will be applied to exploratory investigations into the use of microwave techniques for achieving direct measurement of velocity-coupled response. The velocity-coupled application will require design and fabrication of suitable combustion apparatus.

Initial work will begin on improving and expanding combustion stability analysis. Effort on both linear and non-linear aspects of acoustic energy contributions in rocket motors are planned. Major emphasis during the year is expected to be on linear phenomena however.

CFY+2

Final testing and documentation of the effort on direct measurement of pressure-coupled combustion response is expected. Work will continue to perfect a suitable method for directly measuring the velocity-coupled combustion response.

Analytical efforts on linear combustion stability will continue with documentation on the significant advances being completed. An effort to treat selected non-linear acoustic phenomena will be added.

CFY+3

Final testing and documentation of a direct method for measuring velocity coupled combustion response is expected. Major analytical efforts will continue on non-linear stability phenomena with documentation of significant achievements being made where appropriate.

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